AMENDMENTS TO THE SPECIFICATION:

Please amend the paragraph beginning at page 1, line 4, as follows:

The technology disclosed herein~~present invention~~ generally refers to image processing, and in particular to methods and systems for encoding and decoding images.

Please amend the paragraphs beginning at page 3, line 1, through page 3, line 23, as follows:

The technology disclosed herein ~~present invention~~ overcomes these and other drawbacks of the prior art arrangements.

It is a general object of the technology disclosed herein~~present invention~~ to provide an efficient image processing.

It is another object of the technology disclosed herein ~~invention~~ to provide an efficient image encoding and image decoding.

A further object of the technology disclosed herein~~invention~~ is to provide image encoding and decoding adapted for alpha images comprising transparent and/or semi-transparent image elements.

~~These and other objects are met by the invention as defined by the accompanying patent claims.~~

Briefly, the ~~present invention~~ technology disclosed herein involves alpha image processing in the form of encoding (compressing) an alpha image and decoding (decompressing) an encoded (compressed) image.

According to the technology disclosed herein~~invention~~, an alpha image to be encoded is decomposed into a number of image blocks comprising multiple image elements (pixels, texture elements, texels, or volume elements, voxels). An image block preferably comprises eight image elements and preferably has a size of 2^m times 2^n image elements, where m=3-n and n=0, 1, 2, 3, or a size of $2^m \times 2^n \times 2^p$, where m, n, p=0, 1, 2, 3 and preferably m+n+p=3. Each image element in a block is characterized by a color and an alpha or transparency value. The individual image blocks are then compressed

Please amend the paragraph beginning at page 4, line 11, and continuing to page 4, line 18, as follows:

In a preferred embodiment of the technology disclosed herein~~invention~~, an image block can be compressed according one of multiple, preferably two, possible compression modes. The use of two different compression modes provides flexibility to the encoding method by being able to better adapt to the properties of the individual image blocks in the alpha image. As a consequence of having a choice, per block basis, between two different compression modes, the image quality of the processed image is improved compared to the prior art alpha-adapted encoding schemes with a single-mode encoding.

Please amend the paragraph of page 6, line 3, as follows:

The ~~invention~~ technology disclosed herein offers the following advantages:

Please amend the paragraph beginning at page 6, line 14, and continuing to page 6, line 15, as follows:

Other advantages offered by the technology disclosed herein~~present invention~~ will be appreciated upon reading of the below description of the example embodiments~~ of the invention~~.

Please amend the paragraphs beginning at page 6, line 20, and continuing to page 6, line 23, as follows:

FIG. 1 is a flow diagram illustrating an example embodiment of an image encoding method~~ according to the present invention~~;

FIGS. 2A and 2B illustrate example embodiments of an image block~~ according to the present invention~~;

Please amend the paragraph beginning at page 7, line 8, and continuing to page 7, line 9, as follows:

FIG. 7 is a flow diagram illustrating an image decoding method according to the ~~present invention~~ technology disclosed herein;

Please amend the paragraph beginning at page 7, line 19, and continuing to page 8, line 2, as follows:

FIG. 12 is a block diagram schematically illustrating an example embodiment of an image encoder ~~according to the present invention~~;

FIG. 13 is a block diagram schematically illustrating an example embodiment of a block encoder ~~according to the present invention~~;

FIG. 14 is a block diagram schematically illustrating another example embodiment of a block encoder ~~according to the present invention~~;

Please amend the paragraph beginning at page 8, line 9, and continuing to page 8, line 15, as follows:

FIG. 18 is a block diagram schematically illustrating an example embodiment of an image decoder ~~according to the present invention~~;

FIG. 19 is a block diagram schematically illustrating an example embodiment of a block decoder ~~according to the present invention~~;

FIG. 20 is a block diagram schematically illustrating another example embodiment of a block decoder ~~according to the present invention~~;

FIG. 21 is a hardware block diagram schematically illustrating an example embodiment of a block decoder ~~according to the present invention~~;

Please amend the paragraphs beginning at page 9, line 4, and continuing to page 9, line 12, as follows:

The technology disclosed herein~~present invention~~ relates to image and graphic processing, and in particular to encoding or compressing alpha images and decoding or decompressing encoded (compressed) alpha images.

Generally, according to the technology disclosed herein~~invention~~, during image encoding, an alpha image is decomposed or divided into a number of image blocks. Each such image block then comprises multiple, i.e. at least two, image elements having image element associated properties, among others, a certain color and an associated alpha or transparency value. The image blocks are then encoded or compressed to generate an encoded representation of the image.

Please amend the paragraphs beginning at page 9, line 19, and continuing to page 11, line 6, as follows:

The technology disclosed herein~~present invention~~ is well adapted for usage with three-dimensional (3D) graphics and images, such as photos, text and "synthetic" images, all of which can be used in applications, such as games, 3D maps and scenes, 3D messages, e.g. animated messages, screen savers, man-machine interfaces (MMIs), etc., but is not limited thereto. Thus, the ~~invention~~ technology disclosed herein could also be employed for encoding other types of images or graphics, e.g. one-dimensional (1D), two-dimensional (2D) or 3D images.

In the technology disclosed herein~~present invention~~ the expression "image element" refers to an element in an image block or encoded (compressed) representation of an image block. This image block, in turn, corresponds to a portion of an image or texture.

Thus, according to the technology disclosed herein~~invention~~, an image element could be a texel of a (1D, 2D or 3D) texture or a pixel of a (1D, 2D or 3D) image. Correspondingly, an image element could be a voxel in a 3D texture or image. Generally, an image element is characterized by certain image-element-associated properties, such as a color value and an alpha or transparency value. Furthermore, in the following, the term "image" is used to denote any 1D, 2D or 3D image or texture that can be encoded and decoded by means of the technology disclosed herein~~present invention~~.

As was briefly mentioned above, an image element is often characterized by, among others, a color. This color could be a single-component (one-dimensional)

property, typically a grey level or value. In such a case, the color of an image element can take a value from a minimum grey level, e.g. 0, typically representing black to a maximum grey level, e.g. 255, typically representing white. Alternatively, the color of an image element could be a multi-component (multi-dimensional) property, typically comprising three color components. In such a case, the color could be a RGB (Red, Green, Blue) color, a color in the YUV space, a color in the YCrCb space, or any other color space used in image and graphics processing. In the following, the technology disclosed herein~~present invention~~ will mainly be described with reference to RGB color. This should, however, merely be seen as an illustrative, but non-limiting, example of a suitable color format. The corresponding description can, thus, also be applied to other multi-component color formats and single component color formats, e.g. grey level.

In the art of alpha image processing, alpha values are used to represent the transparency property of an image element. Generally, an alpha value is typically defined as alpha_value=1-transparency, if 0≤alpha_value≤1 and 0≤transparency≤1. Thus, an alpha value of 1 corresponds in this definition to non-transparency or opacity (transparency is 0), whereas an alpha value of 0 then represents full transparency (transparency is 1). Although this definition of alpha values is the most common in the art, the technology disclosed herein~~present invention~~ is not limited thereto. Actually, an alpha value of an image element can, thus, according to the technology disclosed herein~~present invention~~ represent any transparency property of that image element depending on the employed alpha value-transparency relationship.

It is anticipated by the technology disclosed herein~~present invention~~ that the image elements of an "alpha image" in addition to their respective alpha values also have associated color values. Thus, an alpha image of the technology disclosed herein~~invention~~ could be a so-called RGBA-image.

Please amend the paragraphs beginning at page 11, line 8, and continuing to page 11, line 23, as follows:

FIG. 1 is a flow diagram of an embodiment of the (lossy) method of encoding an alpha image according to the technology disclosed herein~~present invention~~. In a first step S1, the image is decomposed or divided into a number of image blocks. Each such image block then comprises multiple image elements. In a preferred example embodiment~~ of the invention~~, an image block comprises eight image elements (pixels or texels) and has a size of 2^m x 2^n image elements, where m=3-n and n=0, 1, 2, 3. More preferably, n is 1 or 2. FIGS. 2A and 2B schematically illustrate two examples of an image block 600 with eight image elements 610 according to the present invention. In FIG. 2A, the height is two image elements 610 and the width is four image elements 610, i.e. m=1 and n=2, whereas for the image block 600 in FIG. 2B m=2 and n=1. Correspondingly, when compressing 3D images, a preferred image block size could be 2 x 2 x 2 image elements (voxels).

However, the technology disclosed herein~~present invention~~ is not limited to blocks with eight image elements but could alternatively be used in connection with image blocks having less, e.g. 2 x 2, or more than eight image elements, e.g. 4 x 4 image elements.

Please amend the paragraph beginning at page 12, line 16, and continuing to page 12, line 20, as follows:

In a preferred example embodiment~~ of the invention~~, the alpha modifying codeword is an index or representation allowing identification of an alpha modifier set. This index could then identify or point to the set in an alpha table or codebook comprising several different alpha modifier sets. Each set comprises two or more alpha modifier values, preferably at least four modifier values.

Please amend the paragraph beginning at page 14, line 7 and continuing to page 14, line 14, as follows:

The technology disclosed herein~~present invention~~ is, though, not limited to usage of Table 1, but could use other tables with other alpha modifier sets and values.

Furthermore, for more or less than 16 sets in a table, the size of the alpha codeword might have to be changed. For example, if the table comprises two (3-4, 5-8 or more than 16) alpha modifier sets, the alpha codeword size could be limited to one bit (two bits, three bits or more than four bits). In addition, the number of alpha modifier values per set could differ from four, e.g. five values could be used per set, giving an example of [-8, -2, 0, 2, 8].

Please amend the paragraph beginning at page 17, line 27, and continuing to page 18, line 5, as follows:

In a preferred embodiment of the technology disclosed herein~~invention~~, the color modifying codeword is an index or representation allowing identification of a color modifier set. This index could then identify or point to the set in a color or intensity table or codebook comprising several different color modifier sets. This table could be organized in a similar manner as Table 1, i.e. includes 16 different modifier sets which include symmetrical modifier values and where a first portion of the modifier sets is a factor two of the modifier sets in a second portion.

Please amend the paragraph beginning at page 20, line 26, and continuing to page 21, line 10, as follows:

Color indices pointing to or associated with one of the two color subcodewords are selected in next step S21. In a first embodiment, each image element in the block is associated with a respective color index. However, in a preferred example embodiment ~~of the invention~~, resulting a smaller total size of the compressed block representation, a subset of the image elements in the block is associated with a pre-defined color subcodeword selected from the first or second subcodeword. As a consequence, no selection or assignment of color index has to be performed for this (these) image element(s). For example, the first (last) image element could always be associated with the first (or second) color subcodeword. The color index sequence does then not need to contain a color index for this first (last) image element. As a consequence, the sequence

will only contain 7 color indices in the case of an image block with totally 8 image elements. It is anticipated by the technology disclosed herein~~present invention~~ that more than one image element could be pre-associated with a color subcodeword.

Please amend the paragraphs beginning at page 26, line 10, and continuing to page 26, line 28, as follows:

In a preferred example implementation~~ of the invention~~, the sizes (number of bits) of the resulting block representation compressed are the same irrespective of the compression mode used. In such a case, the total size of the compressed block representation in FIG. 3C is preferably also 64 bits. This can be obtained by using a 1-bit mode index, two 15-bit color subcodewords 710A, 710B, a 6-bit alpha codeword 720, 4-bit alpha modifying codeword 730, 7-bit color index sequence (one 1-bit color index for each image element except the first image element in the block which is pre-defined associated with the first color subcodeword 710A) and 16-bit alpha modifier index sequence 740.

It is expected that a (vast) majority of the image blocks of most alpha images will be compressed according to the first compression mode when employing a choice between the first and second mode. In the above-discussed preferred implementation of the two modes, both modes have access to 63 "useful" bits that can be used for compressing the image blocks. A remaining single bit is then used as mode index. In an alternative example embodiment~~ of the invention~~, a different kind of mode index than a single bit is used. That mode index will then enable a different amount of allocated "useful" bits to the two compression modes but still preserves the total size of the compressed image block.

Please amend the paragraph beginning at page 28, line 15, and continuing to page 28, line 20, as follows:

FIG. 7 illustrates a flow diagram of a method of decoding an encoded image or encoded version of an original image according to the technology disclosed herein~~present~~

~~invention~~. The encoded image basically comprises several encoded representations of image blocks, such as representations 700 of FIG. 3A, 3B or 3C. These encoded block representations are preferably generated by the image encoding method discussed above in connection with FIG. 1.

Please amend the paragraphs beginning at page 29, line 13, and continuing to page 29, line 28, as follows:

The following step S42 generates an alpha representation for the at least one image element based on alpha codeword. In step S43, the alpha modifier to use for the image element that should be decoded is selected. The modifier value is selected from the modifier set provided in step S40 based on the alpha modifier index associated with the image element and found in the alpha modifier index sequence of the compressed block representation. Once the correct intensity modifier value is selected in step S43, the alpha representation of the image element is modified or modulated with this value in step S44. Alpha modification according to the technology disclosed herein~~invention~~ refers to modifying, e.g. adding or multiplying, the alpha representation by the alpha modifier value.

Steps S42 to S44 could be performed for several image elements in the image block (schematically illustrated by line L5). It is anticipated by the technology disclosed herein~~invention~~ that in some applications, only a single image element is decoded from a specific image block, multiple image elements of a specific image block are decoded and/or all the image elements of a specific block are decoded.

Please amend the paragraph beginning at page 38, line 21, and continuing to page 38, line 29, as follows:

The image encoding (image block encoding) and image decoding (image block decoding) scheme according to the present invention could be provided in a general data processing system, e.g. in a user terminal or other unit configured for processing and/or rendering images. Such a terminal could be a computer or a thin client, such as Personal

Digital Assistance (PDA), mobile unit or mobile telephone. Since both encoding and decoding according to the technology disclosed herein~~present invention~~ can be implemented very easily in hardware, software or a combination of hardware and software, the ~~invention~~ technology disclosed herein could with advantage be applied to a thin client.

Please amend the paragraphs beginning at page 39, line 2, and continuing to page 40, line 20, as follows:

FIG. 11 illustrates an image processing terminal 100 represented by a mobile unit. However, the technology disclosed herein~~invention~~ is not limited to mobile units but could be implemented in other terminals and data processing units. Only means and elements in the mobile unit 100 directly involved in the present invention are illustrated in the figure.

The mobile unit 100 comprises a (central) processing unit (CPU) 200 for processing data, including image data, within the mobile unit 100. A graphic system 130 is provided in the mobile unit 100 for managing image and graphic data. In particular, the graphic system 130 is adapted for rendering or displaying images on a connected screen 120 or other display unit. The mobile unit 100 also comprises a storage or memory 140 for storing data therein. In this memory 140 image data may be stored, in particular encoded image data (compressed image blocks) according to the technology disclosed herein~~present invention~~.

An image encoder 210 according to the technology disclosed herein~~present invention~~ is provided in the mobile unit 100. This encoder 210 is configured for encoding an image or texture into an encoded representation of the image (or texture). As was discussed above, such an encoded representation comprises a sequence or file of multiple compressed image blocks. This image encoder 210 may be provided as software running on the CPU 200, as is illustrated in the figure. Alternatively, or in addition, the encoder 210 could be arranged in the graphic system 130 or elsewhere in the mobile unit 100.

An encoded representation of an image from the block encoder 210 may be provided to the memory 140 over a (memory) bus 150, for storage therein until a subsequent rendering of the image. Alternatively, or in addition, the encoded image data may be forwarded to an input and output (I/O) unit 110 for (wireless or wired) transmission to other external terminals or units. This I/O unit 110 can also be adapted for receiving image data from an external unit. This image data could be an image that should be encoded by the image encoder 210 or encoded image data that should be decoded. It could also be possible to store the encoded image representation in a dedicated texture memory provided, for example, in the graphic system 130. Furthermore, portions of the encoded image could also, or alternatively, be (temporarily) stored in a (texture) cache memory, e.g. in the graphic system 130. A big advantage of the cheap (in terms of complexity) and fast decompression of the technology disclosed herein~~present invention~~ is that compressed image blocks may, at least temporarily, be stored in the cache for fast and easy access. This is further facilitated by the high compression rate, which allows four times as much image block data to be simultaneously stored in the cache compared to uncompressed (RGBA8888) block data.

An image decoder 220 according to the technology disclosed herein~~present invention~~ is provided in the mobile unit 100 for decoding an encoded image in order to generate a decoded image representation. This decoded representation could correspond to the whole original image or a portion thereof. The image decoder 220 provides decoded image data to the graphic system 130, which in turn typically processes the data before it is rendered or presented on the screen 120. The image decoder 220 can be arranged in the graphic system 130, as is illustrated in the figure. Alternatively, or in addition, the decoder 200 can be provided as software running on the CPU 200 or elsewhere in the mobile unit 100.

Please amend the paragraph beginning at page 41, line 9, and continuing to page 41, line 17, as follows:

FIG. 12 illustrates a block diagram of an embodiment of an image encoder 210 according to the diversity handling unit~~present invention~~. The encoder 210 typically comprises an image decomposer 215 for decomposing or dividing an input image into several image blocks. The decomposer 215 is preferably configured for decomposing the image into image blocks comprising eight image elements. This decomposer 215 could be adapted for decomposing different input images into image blocks with different sizes. In such a case, the decomposer 215 preferably receives input information, enabling identification of which image block format to use for a given image.

Please amend the paragraph beginning at page 43, line 3, and continuing to page 43, line 9, as follows:

FIG. 13 illustrates a block diagram of an embodiment of a block encoder 300 according to the technology disclosed herein~~present invention~~, such as the block encoder of the image encoder in FIG. 12. The encoder 300 comprises a color quantizer 310 that generates a color codeword that is representation of the colors of the image elements in the image block. An alpha quantizer 320 is provided in the block encoder 300 for generates an alpha codeword that is a representation of the alpha values of the image elements in the block.

Please amend the paragraph beginning at page 44, line 3, and continuing to page 44, line 8, as follows:

FIG. 14 illustrates a block diagram of another example embodiment of a block encoder 300~~ according to the present invention~~. This block encoder embodiment is able to operate according to the two previously described compression modes. The operation of the alpha quantizer 320, alpha modifier provider 330 and error estimator 350 has already been described with reference to FIG. 13 and is not repeated herein.

Please amend the paragraph beginning at page 46, line 3, and continuing to page 46, line 6, as follows:

A preferred example implementation of a color quantizer 310 ~~according to the present invention~~ is illustrated in the block diagram of FIG. 15. The quantizer 310 comprises means 312 configured for determining an average of the colors of the image elements in the image block.

Please amend the paragraph beginning at page 46, line 20, and continuing to page 46, line 26, as follows:

A preferred implementation of an alpha quantizer 320 according to the technology disclosed herein~~present invention~~ is illustrated in the block diagram of FIG. 16. The quantizer 320 comprises means 322 configured for determining an average of the alpha of the image elements in the image block. This average alpha value is then provided to quantizing means 324, which quantizes the average alpha value and generates the alpha codeword from this quantized average alpha value.

Please amend the paragraph beginning at page 47, line 6, and continuing to page 47, line 11, as follows:

A preferred example implementation of an index selector 340 ~~according to the present invention~~ is illustrated in the block diagram of FIG. 17. This index selector 340 comprises an alpha modifier selector 342 for selecting an alpha modifier for each image element in the block. The alpha modifier indices associated with these selected alpha modifiers are then generated and composed into an alpha index sequence.

Please amend the paragraph beginning at page 48, line 2, and continuing to page 48, line 21, as follows:

FIG. 18 illustrates a block diagram of an example embodiment of an image decoder 220~~ according to the present invention~~. The image decoder 220 preferably comprises a block selector 222 for selecting, e.g. from a memory, which encoded image block(s) that should be provided to a block decoder 400 for decoding. The block selector 222 preferably receives input information associated with the encoded image data, e.g.

from a header or a rendering engine. An address of a compressed image block having the desired image element(s) is computed based on the input information. This computed address is preferably dependent upon the image-element (pixel, texel or voxel) coordinates within an image. Using the address, the block selector 222 identifies the encoded image block from e.g. a memory or a cache. This identified encoded image block is then fetched from the storage and provided to the block decoder 400.

The (random) access to image elements of an image block advantageously enables selective fetching and decoding of only those portions of an image that are needed. Furthermore, the image can be decoded in any order the data is required. For example, in texture mapping only portions of the texture may be required and these portions will generally be required in a non-sequential order. Thus, the image decoding of the technology disclosed herein~~present invention~~ can with advantage by applied to process only a portion or section of an image.

Please amend the paragraph beginning at page 50, line 4, and continuing to page 50, line 8, as follows:

FIG. 19 is an illustration of an example embodiment of a block decoder 400 ~~according to the present invention~~. The block decoder 400 comprises a color generator 410 that generates a color representation for the image elements in the image block based on the color codeword. This generator 410 preferably expands the quantized color of the color codeword into a color representation.

Please amend the paragraph beginning at page 51, line 3, and continuing to page 51, line 8?, as follows:

FIG. 20 illustrates a block diagram of another example embodiment of a block decoder 400 ~~according to the present invention~~. This block decoder embodiment is able to operate according to the two previously described decompression modes. The operation of the alpha generator 420, alpha modifier set provider 430 and alpha modifier 450 has already been described with reference to FIG. 19 and is not repeated herein.

Please amend the paragraph beginning at page 52, line 25, and continuing to page 53, line 5, as follows:

FIG. 21 schematically illustrates a possible hardware example implementation of a block decoder~~ according to the present invention~~. The input to the block decoder is an encoded block representation 700 according to FIG. 3B that comprises a 18-bit color codeword 710 (6 bits for each of the red, green and blue component), a 4-bit color modifying codeword 750, a 16-bit color modifier index sequence 760, a 16-bit alpha modifier index sequence 740, a 4-bit alpha modifying codeword 730 and a 6-bit alpha codeword 720. The modifier indices in the two index sequences 740, 760 are organized so that the MSB of the eight color or alpha modifier indices precedes the eight LSB.

Please amend the paragraph beginning at page 54, line 15, and continuing to page 54, line 20, as follows:

In this hardware implementation the alpha modifier 450 comprises an adder 452 and a clamper 454. The alpha modifier value is input to the adder 452 which adds it to the 8-bit alpha value from the extender 425. It is anticipated by the technology disclosed herein~~invention~~ that the adder 452 can be replaced by e.g. multipliers or XOR gates. The output from the adder 452 is forwarded to the clamper 454, which clamps the modified alpha between 0 and 255.